

gas is inversely as its bulk. When the barometer stands at 30 inches and the thermometer at 80°, the elastic force of the vapour of water being 1·010 of an inch of mercury, a cubic foot of air saturated with moisture, would, when dry, contract to 1669·824 inches. This shows that a somewhat different result would attend the use of moist air.

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ART. V.—*The Introduction of Gold to, and the Formation of Nuggets in, the Auriferous Drifts.* By J. COSMO NEWBERRY, B.Sc., Analyst of the Geological Survey of Victoria.

[Read 30th April, 1868.]

At the meeting of the Society in September, 1866, Mr. Chas. Wilkinson read a paper on the growth of nuggets, in which he stated that I was carrying out a series of experiments based on the very interesting discoveries he had made.

Before describing my experiments and their results, it may be well for me to give an abstract of the arguments used for and against the denudation theory and in favour of what seems to some a rather ludicrous idea—the growth of nuggets in the drifts.

Through the kindness of Mr. Ulrich, I have been able to read the latest ideas of the eminent chemical geologist, Professor Bischoff, from whom I shall freely quote.

That some portion of the gold found in the drifts has been derived from the quartz reefs at the same time that the reefs themselves were formed, there can be no doubt, but the absence of large nuggets in the reefs and the marked difference that exists between much of the drift gold and that from the reefs, tends to make us believe that some portion of it had some other origin or was transferred from the reefs to the drifts by some means other than by denudation. Even if we admit that the large nuggets may have been derived from the reefs by denudation—(for there is a theory that the reefs were much richer in the portions removed to form the drifts, than they are as they now exist)—we must remember that the nuggets consist of nearly the heaviest known matter, offering but a very small surface of attack, when compared with the other materials acted on by the same force and at the same time; it therefore appears strange that these

heavy masses should be found at such great distances from any known reef, as nearly all the large nuggets have been. Another point which attracts attention is, that they are sometimes found in the sand overlying the gravel, which is quite inexplicable, if they ever were in motion with the rest of the constituents of the drift, which usually have a regular arrangement from top to bottom. First clay, then sand and fine and coarse gravel.

These objections to the denudation theory are not easily explained away. And then comes the great fact that gold is contained in the iron pyrites which is found in the drifts, assuming the form of roots and branches of trees and also replacing the carbonaceous matter of the other drift wood. Every sample of this pyrites that has been examined has been found to contain gold. In some instances in a quantity equal to forty or more ounces per ton, and this in samples in which no particles could have collected in crevices or cracks.

This proves that gold did exist in the meteoric waters which deposited the pyrites in tertiary times.

Based on these arguments, Mr. Selwyn, some years ago, advanced the hypothesis, "That nuggets may be formed and that particles of gold may increase in size through the deposition of gold from the meteoric waters percolating the drifts, which water, during the time of our extensive basaltic eruptions, must have been of a thermal, and probably of a highly saline character, favourable to their carrying gold in solution."

As Mr. Ulrich points out in his essay on the Mineralogy of Victoria, this view of the character of the meteoric waters in earlier times receives aid from the fact that on our western gold-fields only, where tremendous basaltic eruptions have taken place, all the large nuggets have been found, while on the eastern and northern fields, where basaltic rocks are wanting, or only of very limited extent, the gold is usually fine, and nuggets of more than an ounce in weight very rare.

That gold does exist in solution in some saline waters of the present day has been proved by several analyses, and Mr. Daintree found gold in solution in water taken from a mine in this colony.

Further proof of gold having been in solution at a comparatively recent date, I found when examining the pebbles of the miocene drifts; they are chiefly quartz, and are coated

over with manganiferous brown iron ore, in which I found gold, though I never could detect any in the pebbles when their surfaces were carefully cleaned.

What the gold salt was, whether a chloride, silicate, or sulphide, we have no means at present of ascertaining. And as it may have been in the same solution that deposited the pyrites, which probably contained its iron in the form of protocarbonate with sulphates, it was not easy at first to imagine any ordinary salt of gold existing in the same solution as a protosalt of iron; but this I find can be accomplished with very dilute solutions in the presence of an alkaline carbonate, and a large excess of carbonic acid, both of which are common constituents of mineral waters, especially in Victoria. This is true of chloride of gold, and if the sulphide is required in solution, it is only necessary to charge the solution with an excess of sulphuretted hydrogen; in this manner both sulphides may be retained in the same solution, depositing gradually with the escape of the carbonic acid.

Professor Bischoff has suggested the occurrence of sulphide of gold in meteoric waters, and by experiment he found that it was slightly soluble in pure water. Once formed and present in the water it is, like all other gold salts, easily decomposed. In an experiment I have made, the sulphide of gold was held in a solution by a small quantity of an alkaline bicarbonate. A cube of iron pyrites and a chip of wood were introduced, and in a few days small irregular grains of metallic gold were deposited on the pyrites. What part the organic matter took in the reaction is not clear, but the gold was not deposited in the absence of it.

In Mr. Chas. Wilkinson's paper, a series of experiments are described in which gold was deposited in the metallic form upon a nucleus, from a solution of the chloride by the reducing agency of organic matter, the nuclei being either gold itself, or iron, copper, and arsenical pyrites, galena, zincblende, sulphide of antimony, etc. Organic matter has long been known as an agent for precipitating gold in the metallic state from its solutions.

Rose states that oxalic acid precipitates it in metallic laminae. This I have failed to produce. When boiled with a solution of chloride, I got purple and red precipitates, but when allowed to remain at the temperature of the air for some hours, a film of gold floated on the surface of the liquid, and

the bottom and sides of the vessel were gilded. Tartaric, citric, and other organic acids have much the same effect. With wood, bark, charcoal, and like substances, the reduction is much slower. No carbonic acid is seen rising, and the gold is deposited in the pores of the reducing agent, if the solution is dilute. But it was not known until the experiment of Mr. Daintree, and the following ones made by Mr. Wilkinson, that this deposit would take place on a nucleus, and be continued as long as gold remained in solution. If this action went on in the drifts, it would account for the greater purity of the gold and for the nucleus of brown iron ore so often found in nuggets and crystals. Strong solutions of gold immediately begin to decompose the pyrites and interfere with the regular deposition of gold. By a strong solution, I refer to one containing more than one grain of chloride of gold to the ounce of water. A weaker solution than this also decomposes the pyrites, but so slowly as not to interfere with the deposit taking place regularly; all the other sulphides are also decomposed. In the experiment in which galena was used as a nucleus, this decomposition was best marked. Somewhat more than a year ago I placed a cube of galena in a solution of chloride of gold, with free access of air, and put in organic matter: gold was deposited as usual, in a bright metallic film, apparently completely coating the cube. After a few months the film burst along the edges of the cube, and remained in this state with the cracks open, without any further alteration in size or form being apparent. Upon removing it from the liquid a few days ago, and breaking it open, I found that a large portion of the galena had been decomposed, forming chloride and sulphate of lead, and free sulphur which were mixed together, encasing a small nucleus of undecomposed sulphate of lead. The formation of these salts had exerted sufficient force to burst open the gold coating—which upon the outside had the mammillary form noticed by Mr. Wilkinson, while the inside was rough and irregular, with crystals forcing their way into the lead salts.

Had this action continued undisturbed, the result would have been a nugget with a nucleus of lead salts, or if there had been a current to remove the results of the decomposition; a nugget without a nucleus of foreign matter. If, instead of galena, we had had a piece of pyrites to start with, the decomposition would have gone on in the same way, but the result would have been brown iron ore in



place of lead salts. This decomposition gives a very simple means of accounting for the oxide of iron, so often found in the nuggets and crystals of gold, the latter especially, as shown by the experiments of the late Dr. Becker, by cutting them in halves, and by their established low specific gravity, and their loss in weight suffered in smelting.

Finding the brown iron ore of the miocene drifts contained gold, I was led to suppose that though I could not make gold deposit on it, I might succeed in making them deposit together, which was the case. I arranged a mass of sand with chips of organic matter in it, in a vessel, and slowly filtered through it a dilute nearly neutral solution of sesquichloride of iron, containing a few drops of chloride of gold, and as it passed through, repeated the dose. This continued for some weeks without any appreciable change taking place, but after some months thin bands of hydrated sesqui-oxide of iron began to form across the mass, about the centre, parallel with the surface. As they increased in size they assumed a botryoidal appearance, like the "ferro-manganese ore" which occurs in the quartz reefs, and in many parts were coated with a bright film of metallic gold. Every further addition of the mixed solution produced another layer of oxide and gold, so that in time it appeared stratified. If the gold had been continued alone after once having started its deposition, the result would have been the same as in the case of the decomposition of pyrites. On the other hand, if the iron solution was in excess after a deposit of gold had been formed, it would have produced what is so often found in the alluvial workings, a nugget coated with iron ore, commonly known as "black gold."

This mixed solution is one which we would not expect to find in nature, but there is no difficulty in supposing the transfer of gold with iron that would deposit as oxide, even, if we need to introduce carbonic acid. If a solution of sesqui-chloride of iron and chloride of gold are heated together, the whole of the gold, in a very finely divided state, with a portion of the iron as sesqui-oxide, is deposited in a brownish yellow precipitate.

Though the processes I have described will account for the formation of nuggets, it does not account for the appearance of the gold in pyrites. I have examined about 100 samples, in none of which do I find any tendency on the part of the gold to assume the form of a coating, it being usually in irregular grains, and small octahedral crystals, seldom to be

detected, even with the aid of the microscope, until nearly all the pyrites has been oxidized and decomposed. In a few exceptional cases pieces have been found projecting, but all tends to prove the priority of the deposition of the gold, and that instead of pyrites having formed a nucleus for the gold, the reverse has in the majority of instances been the case.

It may also have been the first to deposit in the drift wood, for in all the experiments by Mr. Wilkinson and myself the organic structure became so impregnated with gold that when ignited (so as to burn off the undecomposed organic matter) a golden model remained. Flies, which fell into some of my experiments, and were useful in keeping up a supply of fresh organic matter, became so thoroughly impregnated that in some cases the finest hairs on their backs and legs were to be seen in bright gold after ignition. Conditions such as these (before ignition) would be very favourable to the formation of pyrites, offering to a ferruginous water containing sulphates, a reducing agent and congenial nuclei for the crystals to form on. Crystalline gold is very easily made, by simply introducing a chip of wood into a solution of chloride of gold, containing five or six per cent of the salt. The crystals are first seen on the surface of the liquid as a thin film, which, as it grows heavier, falls to the bottom, where it assumes a moss-like appearance; if this is examined under the microscope, it will be found to be a network of octahedral crystals resembling very closely the gold crystals from pyrites. These crystals have been repeatedly made, in a carefully closed vessel, so that no dust might enter, and falling on the surface form nuclei for them. With these crystals I sometimes found irregular pieces of gold, some in places showing planes of octahedrons. In these experiments, as in all the others, organic matter is necessary, the action ceasing when it was removed, starting again immediately with a fresh addition.

These experiments are based on the assumption that the gold exists in the pyrites on the metallic form, and not as sulphide, as has been supposed to be the case by some. Mr. Daintree got gold in solution by digesting some of the pyrites from Clunes in sulphide of ammonium, but I have always failed to prove the presence of it as negative evidence against it. I have the result of experiments made by digesting the pyrites with an oxidizing agent, washing the residue free from impurities, weighing the gold and comparing the result with that got from a portion of the

same sample made by the ordinary fire assay, and finding that they agreed.

If sulphide of gold has existed in the metallic waters, we might expect in some cases to find it, but, as before noticed, it is so easily decomposed, that it is not possible for much to have resisted the heat caused by the basaltic eruptions.

I have experiments now in progress which contain the sulphides of iron and gold in solution, but up to the present time without any result, in this direction. Like some of the others I have spoken of, they may require a year or more to accomplish the end wished for.

Professor Bischoff suggests silica as the medium for the transmission of gold to the quartz reefs, gold, as he points out, certainly has a great affinity for silica, always being found in connection with it in mineral veins in the drifts, and even in the pyrites, where I have always found silica as grains, and minute nearly perfect hexagonal crystals; the occurrence of which I have always been at a loss to account for.

The Professor's experiment is a very instructive one. He reports it as follows:—On adding to a solution of chloride of gold a solution of silicate of potassa, the yellow colour of the former disappears. After half an hour the fluid turns blue, and in time a gelatinous dark blue precipitate appears, which adheres firmly to the vessel. After the lapse of some days moss-like forms are to be seen on the surface of the precipitate like an efflorescence; on exposure to sunlight, no reduction takes place, but after the lapse of some months, if the precipitate is allowed to remain undisturbed under water, a decomposition takes place, and in the silicate of gold appear minute partly microscopical specks of gold.

If this is the method by which the gold reached the lodes, as the Professor argues, the origin of the silica may also be that of the gold. The origin of the former we now believe to be the silicates of the rocks, by the decomposition of which by mineral waters the silica is conducted to the lode cracks. In these silicates we have therefore to look for gold; and it is possible that it is contained in them as silicate. To prove this is almost impossible, for if we even found the gold it would be in a quantity too small to determine whether it was in combination or not.

Silicate of gold is extremely insoluble in water, but if we assume that its solubility is in the same ratio to the solubility of silica as the gold of even our richest reefs is

to the silica in the reef, we will find no difficulty in admitting that silicate of gold may exist in solution.

In several instances an amethystine colour has been observed, both in the quartz reefs and in the "washdirt" of the drifts. Mr. Aplin tells me that he observed it in a lead of washdirt near Beechworth. When pieces of the clay so coloured were first broken out no gold was to be seen; but after exposure to the light and air for a short time the colour disappeared, and it was seen to be full of very finely divided gold. Mr. Ulrich also tells me that this colour and phenomena were observed by a Mr. Clement, a successful quartz miner, of Maldon, who described having found dark blue clayey bands in the centre of a quartz reef, some ten feet thick, at a depth of about seventy feet from the surface. The colour in this case, as in that reported by Mr. Aplin, disappeared when exposed to air and light, and gold became visible. It is to be regretted that no chemical examination was made, as there was undoubtedly a compound of gold present.

Be this as it may, there can be no doubt that nearly all the native sulphides contain gold, especially those which also contain silver. I have found it with this metal in every sample of iron, copper, and arsenical pyrites galena, sulphide of antimony and zinc blended, which I have examined from the rocks of this colony; and Dr. Percy proved its existence in every sample of galena he examined, even though they contained little or no silver. Bischoff, in reviewing facts like these, says that it has been repeatedly proved that in the decomposition of ore lodes, the silver takes part in the oxidation processes, and is removed in soluble combinations. If such ores are auriferous, and after such a decomposition the lodes undergo mechanical destruction, the gold will, as it is in a very minute state, be carried off with the results of the decomposition. The argentiferous character of the native gold, and the auriferous character of native silver, show that though one metal passed into a soluble form and the other remained metallic; the separation was not complete.

In this very minute state gold may possess properties differing from those which it has when in mass. Iron, for instance, when reduced by hydrogen from the oxide, has such a great affinity for oxygen, that, if dropped through the air at the ordinary temperature it takes fire, whilst ordinary iron filings, under similar circumstances, are not affected.



It is therefore possible that gold, under certain circumstances, may, by the presence of silica in solution, become disposed to combine with oxygen, and then to form with the silica a silicate of gold.

If further experiments prove that alkaline silicates favour the solubility of silicate of gold, this silica theory will be open to but few objections, and the difficulties to impede our progress in solving this most interesting problem in chemical geology will be greatly diminished, as it will not require the presence of strong chemical agents, which are not to be found either in the rocks, or in the meteoric waters percolating through them.

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ART. VI.—*Aneroid Barometers, and the Methods of Obtaining their Errors.* By MR. R. L. J. ELLERY, President.

[Abstract, Read 11th May, 1868.]

In this paper the President referred principally to the construction, mode of using, and the correction of errors of aneroid barometers. He pointed out the great utility of these, both as scientific instruments and domestic weather-glasses, as well as of their great value as marine barometers. He drew attention to the absurdity of the ordinary printed words on barometers, as being quite inapplicable, at all events to this climate, and stated that the point marked "stormy," namely twenty-eight inches, was seldom or never reached in these latitudes, and that our most violent storms occurred with a much higher barometer. He then gave the following series of directions, for the guidance of those using the barometers as a weather-glass in Melbourne and its neighbourhood:

It should always be remembered that the barometer foretells *coming* weather rather than indicates weather that is *present*; that the longer the time between the signs and the change foretold by them the longer such altered weather will last; and on the contrary, the less the time between a warning and a change the shorter will be the continuance of such predicted weather. If a barometer is about at its ordinary height—near thirty inches at the sea level—and is steady or rising while the thermometer falls, S.W., S., and S.E. winds may be expected. On the contrary, if a fall takes place with a rising thermometer, wind and